Volume 2, Issue 8, August 2012 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

MSPA for Electronic Toll Collection

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Abstract: **The Electronic Toll Collection (ETC) is a technology that permits vehicles to pay highway tolls electronically. This automation has replaced live attendants at toll stations that collect fees manually. Some tags are designed to communicate with other kinds of roadside readers as well, making interstate and intrastate toll payments accessible. Toll agencies are interested in developing these tags and readers because they can simplify the tolling system. This paper deals with the design and analysis of MSP Antenna, which will place at the toll gates to sense the information about toll payment process with the help of some advanced circuitry.**

Keywords: **Microstrip Patch Antenna (MSPA), Electronic Toll Collection (ETC), Tags**.

I. INTRODUCTION

However, when a vehicle enters a distanced-based road, such as the turnpike, the computer stores the vehicle's point of entry, and calculates and assesses when the vehicle entered and exited the toll facility. Transactions are performed while the vehicle is within 40 meters of the antenna's reach. The advantages includes makes traveling more convenient, reduces travel times, saves fuel, reduces auto emissions, reduces wait time at toll booths, save money through individual and business discounts, increase highway capacity, processes 250 – 300% more vehicles per lane, reducing delays and traffic congestion[1-2].

The current work deals with the design of MSPA for electronic toll collection system and its performance parameters will be simulated and verified with standard requirement.

II. COMPONENTS OF ELECTRONIC TOLL COLLECTION SYSTEM

Automatic Vehicle Identification, Automatic Vehicle Classification, Video Enforcement System are the basis for this electronic toll collection system. The vehicle identification will takes the help of electronic tags, identifies account and deduct the charges from the vehicle owner. Vehicle classification will be done using sensors and vehicle class [3]. Vehicle enforcement consists of video monitoring, records plates and identifies toll violators. Automatic Vehicle Identification tags are electronically encoded with unique identification numbers. Roadside readers or antennas are located along the road, in overhead structures or apart of the toll collection booth [4-5].

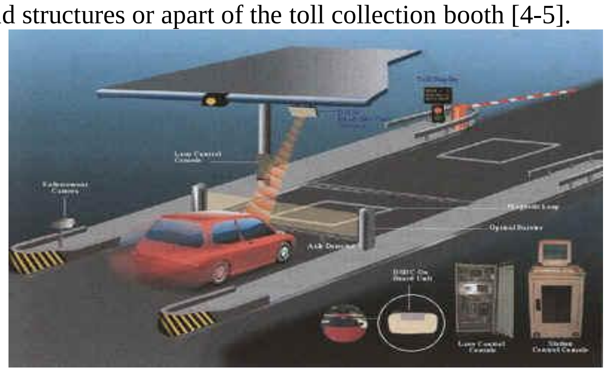

Figure 1. Toll Collection System

The identification number is read and is sent to a roadside reader unit where it receives a time, date and location. A central computer uses the code to identify the account and the cost is deducted from the customer's account. The type of automatic vehicle identification tag signal that is most commonly used for electronic toll collection is radio frequency. While other types of signals such as laser and infrared (IR) have been tested and deployed, Radio Frequency tags currently provide the most accurate results [6-7]. Automatic vehicle identification tags can be further broken down into distinct tag types based on the degree to which they can be programmed and the type of power source.

III. ADVANTAGES AND DISADVANTAGES OF ELECTRONIC TOLL COLLECTION

The advantages of electronic toll collection includes the traveling more convenient, reduces travel times, Saves fuel, Reduces auto emissions, Reduces wait time at toll booths, Save money through individual and business discounts, Increase highway capacity, Processes 250 – 300% more vehicles per lane, reducing delays and traffic congestion. The disadvantages are job loss, Theft of Stolen tags, Account tampering and financial loss, Incorrect reads, Fines for motorist, monetary loss for company [8].

IV. RESULTS AND DISCUSSION

One of the primary results from the antenna simulations are the S-parameter (Magnitude and Phase) plots versus frequency. The S-Parameters plot show resonance frequencies and operating bandwidths for the microstrip patch antennas analyzed. Figure 2 shows the return loss curve for the antenna, which is giving -11.2dB at 5.8 GHz.

A Smith chart shows complex values of the reflection coefficient $S11$, also referred to as Γ. Since Smith charts are defined only for the input and output reflection parameters ($S11$, $S22$ etc.) only these values can be plotted. Figure 3 shows the input impedance smith chart for the proposed antenna and it is having the impedance bandwidth of 0.8%.

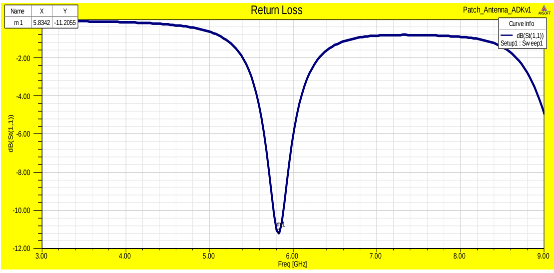

Figure 2. Return Loss of ETC-MSPA

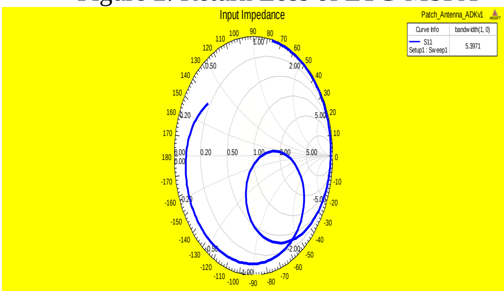

Figure 3. Input impedance smith chart

Figure 4 shows the VSWR curve for the proposed antenna, which satisfies the condition of 2:1 at desired frequency. The VSWR obtained here is in the range of 1.7, which is nearer to 1.5 and below the value 2.

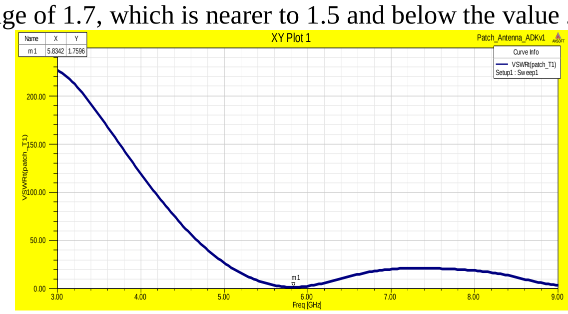

Figure 4. VSWR Curve

Figure 5 shows the gain plot for the antenna with the gain of 7.5dB.

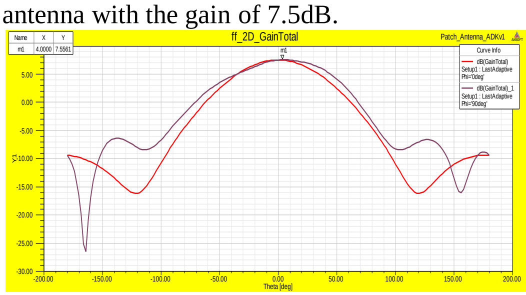

Figure 5. Gain Plot

The directivity is indicated by both the distance from the origin in the particular direction (defined by the angles of azimuth phi and the zenith angle theta) and the directivity surface colour. Figure 6 and 7 shows the directivity plots for the antenna. The polar plots present the far-field magnitudes with one coordinate varying and one fixed.

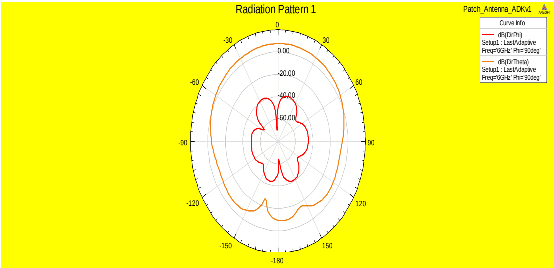

Figure 6 Cross Polarization Radiation Pattern

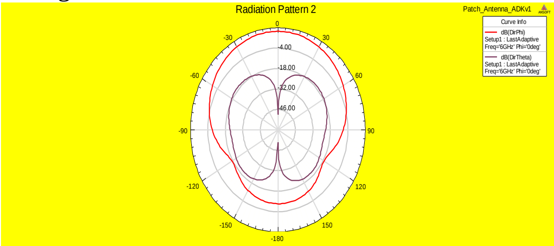

Figure 7 Co-Polarization Radiation Pattern

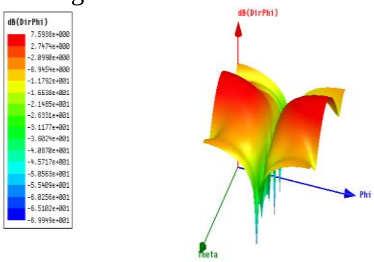

Figure 8 Radiation Pattern in Phi Direction

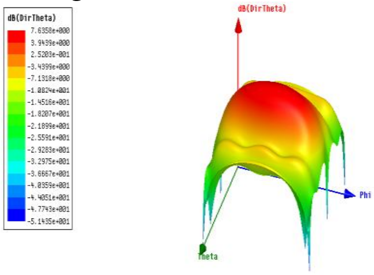

Figure 9 Radiation Pattern in Theta Direction

Figure 8 and 9 shows the radiation pattern of the antenna in three dimensional view.

V. CONCLUSION

Radio frequency will emit from installed antennas to freeway lanes. As a vehicle containing a tag pass, the antenna emits a signal that is reflected back by the tag located on the windshield of a vehicle. Once the identification number is read, it is sent to a roadside reader that records the time, date and location of use. The results showing the applicability of the current antenna for the purpose of ETC with moderate gain of 7.5dB and bandwidth of 0.8%.

ACKNOWLEDGMENTS

Authors like to express their thanks to the management of K L university and management of SRKR Engineering college for their support and encouragement during this work. Further Madhav likes to express his gratitude towards Chancellor Sri K. Satyanarayana garu and Prof. VGKM Pisipati for providing excellent R&D facilities at KLU. Mohan Reddy expresses his profound gratitude to Sri S. Vithal Ranga Raju , Honorary Director and Dr. D. Ranga Raju, Principal SRKR Engineering college for their encouragement and support in making out this work.

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